As Darby infers, the Mississippi formerly flowed west of its present channel. It was separated from the Ohio by an interfluve, the remnants of which are the "continuous ridge" mentioned by Hall. By two successive captures the Ohio diverted the Mississippi; the final capture led the Mississippi through its present gorge where the "masses of limestone rock are seen on either side."

Henri Peyroux de la Condreniere, commandant at Ste. Genevieve from 1787 to 1796, was a man of considerable scientific ability. In one of his essays he maintains that the Great Lakes formerly discharged into the Mississippi by way of the Illinois River. He reasons that the valley is too wide and deep to have been eroded by the present Illinois River. Another reason quoted is not so well founded; the "vast alluvium" stretching along the Mississippi to the Gulf is also held to indicate a drainage from the Great Lakes. This conjecture is an interesting prelude to the work which has shown the extent and drainage of those great marginal glacial lakes that preceded the present Great Lakes. The quotation has been handed down by Brackenridge, the lawyer-traveler in his "Recollections of the West," second edition, Philadelphia, 1868 (page 241). He (Brackenridge) adds prophetically "At no distant day the labor and ingenuity of man will restore the connection between the Lakes and the Mississippi by means of an artificial channel."

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SPECIAL ARTICLES

HORNS IN SHEEP AS A TYPICAL SEX-LIMITED CHARACTER[1]

Several years ago Wood (1905) published a note in which he showed that, in a cross between a Dorset Horn and a Suffolk (belonging to a hornless breed of sheep), the male offspring all developed horns but the female offspring remained hornless. He showed further that in the F_2 generation hornless males arise, and these do not carry the determiner for horns, and horned females, but only when they have the determiner duplex. Bateson (1909, p. 173) has discussed these facts and drawn the conclusion: "Sex itself acts as a specific interference, stopping or inhibiting the effects of a dominant factor, and it is not a little remarkable that the inhibition occurs always, so far as we know, in the female, never in the male." He admits, however, the difficulty in distinguishing between this probability and the other possibility; viz., that the male provides a stimulating factor. Castle (1911, p. 102) concludes that the reason horns are more strongly developed in males than females is "the presence of the male sex-gland in the body, or rather probably some substance given off into the blood from the sex gland, favoring growth of the horns"; and he adds that if the male Merino sheep (in which, usually, the male, and the male only is horned) is castrated early in life no horns are formed. He gives no reference for the last statement; and in view of the variability of the horned condition in the males of the "Merinos" the conditions of the experiments would have to be carefully considered before such a result could be accepted as settling the question of the dependence of horns in heterozygous males upon a secretion from the testis.

The hypothesis that we have adopted and which works with entire satisfaction assumes, first, that, as in man so in sheep, the male is heterozygous (simplex) in sex. One sex-chromosome is then to be expected in the male, and substantially this condition has been found to hold for man by Guyer (1910). The female will then be duplex in respect to sex. One further assumption is necessary; there is an inhibitor to horn formation, and this is located on the sex chromosome; consequently it is simplex in the male and duplex in the female. Thus it belongs to the well-known class of sex-limited characters. The inhibi-

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Determiners in Germ Plasm of		No. of Horned and Hornless Offspring			
Male	Female	Males		Females.	
		Horned	Hornless	Horned	Hornless
Soma *XxhhIi* (hornless)	*XXhhII* (hornless)				
Gametes *XhI*	*XhI*				
xhi					
Zygotes *XxhhIi* (hornless)	*XXhhII* (hornless)	0	4	0	12
Soma *XxhhIi* (hornless)	*XXHhII* (hornless, simplex)				
Gametes *XhI*	*XHI*				
xhi	*XhI*				
Zygotes *XxHhIi* (horned)	*XXHhII* (hornless)	(2)	(2)	(0)	(2)
XxhhIi (hornless)	*XXhhII* (hornless)	2	2	0	2
Soma *XxhhIi* (hornless)	*XXHHII* (horned)				
Gametes *XhI*	*XHI*				
xhi					
Zygotes *XxHhIi* (horned)	*XXHhII* (hornless)	15	0	0	24
Soma *XxHhIi* (horned, simplex)	*XXhhII* (hornless)				
Gametes *XHI*	*XhI*				
XhI					
xHi					
xhi					
Zygotes *XxHhIi* (horned)	*XXHhII* (hornless)	(.5)	(.5)	(0)	(8)
XxhhIi (hornless)	*XXhhII* (hornless)	0	1	0	8
Soma *XxHhIi* (horned, simplex)	*XXHhII* (hornless, simplex)				
Gametes *XHI*	*XHI*				
XhI	*XhI*				
xHi					
xhi					
Zygotes *XxHHIi* }	*XXHHII* (horned)				
XxHhIi } (horned)	*XXHhII* }				
XxHhIi }	*XXHhII* } (hornless)	(7.5)	(2.5)	(2)	(6)
XxhhIi (hornless)	*XXhhII* }	6	4	1	7
Soma *XxHhIi* (horned, simplex)	*XXHHII* (horned)				
Gametes *XHI*	*XHI*				
XhI					
xHi					
xhi					
Zygotes *XxHHIi* (horned)	*XXHHII* (horned)	(10)	(0)	(4)	(4)
XxHhIi (horned)	*XXHhII* (hornless)	10	0	4	4
Soma *XxHHIi* (horned)	*XXhhII* (hornless)				
Gametes *XHI*	*XhI*				
Hhi					
Zygotes *XxHhIi* (horned)	*XXHhII* (hornless)	5	0	0	8
Soma *XxHHIi* (horned)	*XXHHII* (horned)				
Gametes *XHI*	*XHI*				
xHi					
Zygotes *XxHHIi* (horned)	*XXHHII* (horned)	6	0	14	0

tor, then (designated in the table by the letter *I*, its absence by *i*), will always be double in the female and single in the male and, in the gametes, will always be associated with the sex-chromosome, which is designated throughout by the symbol *X*; its absence by *x*. In the zygote the single inhibitor is incapable of preventing the development of the determiner for the horn (*H*) even when the latter is only simplex. But the double inhibitor is capable of preventing the single horn (*Hh*) determiner, but not the double determiner (*HH*).

The table gives a summary of matings used, their hypothetical somatic and gametic composition, and the proportion of each sort of zygote that will be formed in each sex.

The actual frequency of offspring derived from each mating is given on the left of the table; the expected proportions in the more complex cases being given above the actual findings in parenthesis. The matings were made and the offspring examined in major part at the New Hampshire Agricultural Experiment Station and in minor part at the Station for Experimental Evolution. The latter station was able to contribute especially to the results of later generations. For horned females, Dorsets were used; for horned males Rambouillets, Dorsets and the Scottish 4-horned race. As hornless races the Downs were chiefly employed. It is not our purpose now to give complete details, as the experiments are being continued and full data will be deferred until the publication of our final report.

The results of the table accord very closely with expectation, so that we are justified in concluding that an explanation of the results like that we offer is the correct one. By our formula, then, the case of inheritance of horns in sheep is brought quite into line with that of other sex-limited characters, its peculiarities being due to an inhibitor of horn development that is carried in the sex-chromosome.

LITERATURE CITED

Bateson, W., 1909, "Mendel's Principles of Heredity," Cambridge, Eng., University Press.

Castle, W. E., 1911, "Heredity in Relation to Evolution and Animal Breeding," New York, Appleton.

Guyer, M. F., 1910, "Accessory Chromosomes in Man," *Biol. Bull.*, XIX., 219–234, Pl. I.

Wood, T. B., 1905, "Note on the Inheritance of Horns and Face Color in Sheep," *Jour. Agric. Sci.*, I., 364, 365, Pl. IV.

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THE "STOMACH STONES" OF REPTILES

GASTROLITHS have been known to occur, mingled with the remains of extinct reptiles, for many years and much attention has been called to them in the pages of SCIENCE and elsewhere, especially by Mudge, Seeley, Williston, Eastman, Wieland and Brown. Interesting parallels have been cited among several living vertebrates. There has been some contention that the stones were taken for the purpose of a "gastric mill," but they were in part at least accidental. There seems to be some evidence for the conclusion that the plesiosaurs, at least, selected stones for this purpose, though this may have been more accidental than we think. Recently there has been brought to my attention by Mr. Edward Taylor, of the University of Kansas, an interesting case of stone swallowing by a lizard, *Phrynosoma cornutum* Harlan. Only a single specimen is at hand for the data, but it is of sufficient interest in connection with identical habits among fossil reptiles to be recorded. The horned "toad" in question is a very large adult female collected by the late Dr. F. H. Snow in the Magdalen Mountains of New Mexico. In the stomach were twenty large, somewhat abraded stones of a rock which resembled lava. Some of the stones are very large, for the size of the animal, measuring nearly a third of an inch in diameter. There were also in the stomach about 200 of the large red ants, of an undetermined species, which make the large mounds so common to the western traveler. The animal had undoubtedly picked up the stones with the ants from the top of the mound and the association is probably accidental. That they served the purpose of a "gastric mill" once inside the digestive canal can not be doubted, whether the animal willed or no.

In this connection it may be of interest to the readers of these pages to call attention to some large Cretaceous sharks which have, within the past few months, been received at the University of Kansas Museum. In one specimen, consisting almost entirely of scattered vertebral cartilages, there are associated many hundreds of greatly abraded, very smooth and polished stones of white and black quartzite. That they belong with the shark can not be doubted on account of the